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(54) **Supply circuit for gas discharge lamps**

(57) The invention relates to a circuit for supplying at least one gas discharge lamp (15,16) from a power source (3), comprising a frequency converter (1) connectable to the power source (2) for supplying the gas discharge lamp (15,16) with a basic frequency which is higher than the supply frequency, an inductive ballast (19,20) connected in series to the gas discharge lamp (15,16), and a starter circuit (17,18), wherein the inductive ballast (19,20) at least forms part of the starter circuit (17,18).

As a result of these steps at least a part of the inductive ballast (19,20) fulfills a dual function; it fulfills its classic function of ballast and furthermore its function as part of the starter circuit (17,18).

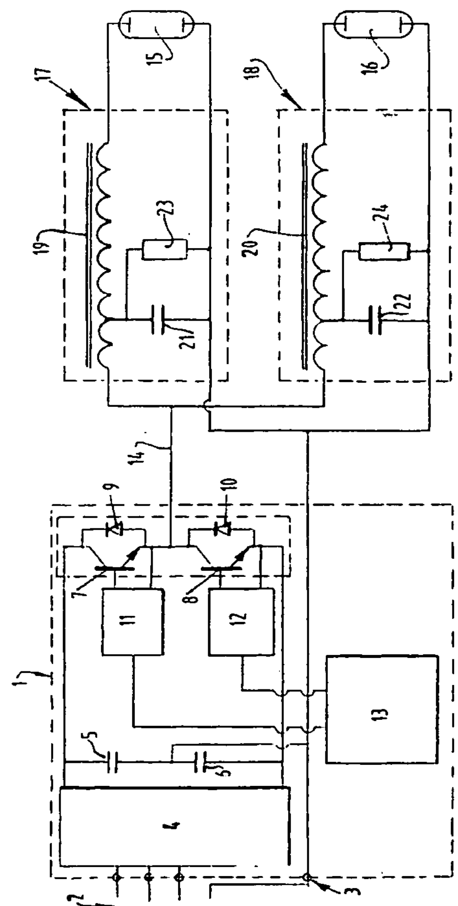

FIG.1

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Description

The invention relates to a circuit for supplying at least one gas discharge lamp from a power source, comprising a frequency converter connectable to the power source for supplying the gas discharge lamp with a basic frequency which is higher than the supply frequency, an inductive ballast connected in series to the gas discharge lamp, and a starter circuit.

Such circuits are generally known.

These prior art circuits are provided with a separate starter circuit, whereby the number of components of such prior art circuits is considerable.

Such starter circuits moreover require separate control circuits, whereby the number of components and the complexity is increased still further.

The object of the present invention is to provide such a circuit, wherein the number of components is considerably smaller.

This object is achieved in that the inductive ballast at least forms part of the starter circuit.

As a result of these steps at least a part of the inductive ballast fulfills a dual function; it fulfills its classic function of ballast and furthermore its function as part of the starter circuit. This results in a considerable reduction in the number of components.

According to a preferred embodiment the inductive ballast is provided with an intermediate tap.

This step makes it possible that voltages generated by the starter circuit in the one part of the ballast are increased in the other part of the inductive ballast due to the inductive ballast provided with an intermediate tap acting as autotransformer. The relatively high ignition voltage is hereby obtained, so that the starter circuit does not per se have to generate a particularly high voltage.

According to a further preferred embodiment the intermediate tap of the inductive ballast is connected by means of a capacitor to a terminal of a gas discharge lamp which is not connected to the ballast.

A resonant circuit is hereby obtained which is formed by the first part of the inductive ballast and the capacitor, which resonant circuit serves as starter circuit. It is noted here that the resonance frequency of this resonant circuit is high, i.e. at least several orders of magnitude higher than the generally usual mains frequencies, so that without further steps such a circuit would not operate when fed by the distribution network because the individual frequency of the circuit lies outside the provided spectrum. On the other hand, as a consequence of the fact that in the present invention a frequency converter is used which generates a voltage signal with a broad frequency spectrum, it is possible that the individual frequency of the resonant circuit is present in the provided spectrum and the resonant circuit is thus excited.

According to a further embodiment a resistor is connected in parallel to the capacitor. This resistor serves to discharge the capacitor.

According to yet another embodiment the capacitor is connected by means of a controllable switch element to the terminal of the gas discharge lamp which is not connected to the ballast. This results in the possibility of the starter circuit being interrupted after a starting period, which is particularly important in case of a defective lamp; this in any case prevents the starter circuit remaining operational when a lamp does not start and the inductive ballast being subjected to voltages.

Further attractive preferred embodiments are found in the remaining sub-claims.

The invention will be further elucidated hereinbelow with reference to the annexed drawings, in which:

figure 1 shows a diagram of a first circuit according to the invention;
figure 2 shows a diagram of a second circuit according to the invention;
figure 3 shows a diagram of a third circuit according to the invention; and
figure 4 shows a diagram explaining the operation of the invention.

Shown in figure 1 is a frequency converter 1 which is connected to an alternating current supply mains 2 which is formed by four conductors, i.e. the three phases and a neutral conductor. The terminal 3 arranged for this purpose leads to a rectifier 4 which forms part of the frequency converter.

Connected to the output terminals of the rectifier 4 are smoothing capacitors 5,6 which are connected in series. The central point between the two smoothing capacitors 5,6 is connected to the neutral conductor. In order to generate the voltage with the high frequency the output terminals of rectifier 4 are connected to two switch elements 7,8 which are connected as a half-bridge.

In the present case these switch elements are formed by transistors, although it is likewise possible to make use for this purpose of other switch elements, for instance IGBTs, FETs, GTO-transistors or thyristors which must of course be provided with a quenching circuit suitable for this purpose. Each of the switch elements is provided with a freewheel diode, the use of which will be apparent to the skilled person.

In order to control the transistors use is made of a drive circuit 11 respectively 12. The relevant circuits are connected to the control electrode of the switch elements and thus in the present case to the base of the transistor. Each of the drive circuits 11,12 is connected to a control circuit 13. The latter generates pulses to the relevant drive circuits 11,12 for opening or closing the respective switch elements 7, 8. In order to prevent short circuit, the control circuit ensures that only one of the two switch elements is conductive, wherein the control is performed such that a pulse-like voltage results at the junction between the two switch elements, which juncconstantly loaded with high voltage pulses.

It is otherwise pointed out that it is known that the colour quality of high pressure sodium lamps can be improved by pulse current action, see the publication ■The High Pressure Sodium Lamp■ (ISBN 90 201 19028). For this purpose the lamp current must be brought to a high peak value during a fraction of the conduction.

This can be realized with the system of this invention by placing two ballast coils in series. A first coil, which according to the foregoing is already present, then has a high induction value and a low saturation current and a second, additionally arranged coil has a low induction value and high saturation current. The first coil will limit the current until the magnetic material of the core reaches saturation; the current will then increase sharply and is only limited by the lower induction value of the second coil which is dimensioned such that it will not reach saturation.

Figure 3 shows an embodiment of the circuit according to the invention, which is in particular fit for being supplied by a single DC-voltage source which is depicted in figure 3 through a full-bridge rectifier 35. The circuit according to figure 3 comprises, in contrary to the circuit of figure 2 which is also fit for being supplied by a single supply 25, only one pair of switching elements 7,8. In the circuit according to figure 3 the switching elements 28,29 and the related control electronics are deleted. This is only possible by the addition of a capacitor 36 in series with the lamp 15.

This capacitor allows a certain form of resonance, so that the two additional switching elements can be deleted. Another advantage of the circuit resides in the fact that the resonance may lead to a better switching efficiency.

The circuit has, however, the disadvantage that the capacitor 36 is rather bulky. Only when the frequency is sufficiently high, for instance above 30 kHz, it is possible to use a capacitor with such a small value, that the volume thereof is acceptable.

It will be clear that it is possible to deviate from the description on several ways without leaving the scope of the annexed claims.

Claims

1. Circuit for supplying at least one gas discharge lamp from a power source, comprising a frequency converter connectable to the power source for supplying the gas discharge lamp with a basic frequency which is higher than the supply frequency, an inductive ballast connected in series to the gas discharge lamp, and a starter circuit, **characterized in that** at least a part of the inductive ballast forms part of the starter circuit.

2. Circuit as claimed in claim 1, **characterized in that** the inductive ballast is provided with an intermediate tap.

3. Circuit as claimed in claim 2, **characterized in that** the intermediate tap of the inductive ballast is connected by means of a capacitor to the terminal of the gas discharge lamp which is not connected to the inductive ballast.

4. Circuit as claimed in claim 3, **characterized in that** a resistor is connected in parallel to the capacitor.

5. Circuit as claimed in claim 3 or 4, **characterized in that** the capacitor is connected by means of a controllable switch element to the terminal of the gas discharge lamp which is not connected to the ballast.

6. Circuit as claimed in any of the foregoing claims, **characterized in that** the frequency converter is provided with a direct voltage intermediate circuit with capacitors which is fed by a rectifier circuit which is connected to a mains supply comprising a neutral conductor and which is connected by a half-bridge of switching semiconductors to the series connection of the ballast and the lamp, which series connection is otherwise connected to the neutral conductor.

7. Circuit as claimed in any of the claims 1-5, **characterized in that** the frequency converter is provided with a direct voltage intermediate circuit with capacitors which is fed by a rectifier circuit which is connected to a mains supply and which is connected by two half-bridge circuits of switching semiconductors to the series connection of the ballast and the lamp.

8. Circuit according to one of the claims 1-5, **characterized in that** a capacitor is connected in series with the lamp, that the frequency converter is supplied by a DC-voltage source, and that the frequency converter comprises two switching semiconductors in the configuration of the half-bridge.

9. Circuit as claimed in any of the foregoing claims, **characterized in that** the frequency converter is adapted to generate voltage pulses, the width of which is modulated such that in the circuit formed by the inductive ballast and the gas discharge lamp a current is created with a repetitive pattern.

10. Circuit as claimed in claim 9, **characterized in that** the repetitive pattern is an approximation of a sine.

11. Circuit as claimed in claim 9, **characterized in that** the repetitive pattern is an approximation of a trapezium.

tion is designated with 14.

It is pointed out here that the waveform of the switching pulses of the switch elements is represented in the top half of the diagram shown in figure 3. This shows that the switching pulses have a fixed frequency and that their width is controlled such that the resulting voltage forms an approximation of a sine-shaped signal. A substantially sine-shaped current hereby results, as shown in the bottom half of figure 3, which is of course shifted in phase by the inductive load, wherein the frequency of the substantially sine-shaped signals is roughly one order of magnitude higher than that of the usual supply voltages. Owing to the sine shape of these signals a reduction in the iron losses in the inductance is achieved.

It is of course possible to cause other than sine-shaped resulting voltages to be generated, for instance trapezium-shaped voltages. This may result in a reduction of the switching losses in the switch elements. The choice thereof will have to be determined by optimizing a particular application.

In the embodiment shown in figure 1 two lamps 15,16 are connected to the frequency converter 1. Each of the lamps is provided with a compensation device 17,18 respectively which is formed by a ballast 19,20 respectively. Each of the ballasts 19,20 respectively is provided with an iron core which is represented by means of a dash in the figure. The ballasts 19,20 each have the configuration of an autotransformer. This means that they are provided with an intermediate tap, wherein both thus formed parts of the self-induction are in any case mutually coupled, so that the operation of an autotransformer is obtained. The intermediate tap of each of the inductances is connected by means of a capacitor 21,22 respectively to the neutral conductor and thus to the other side of the lamps. Connected in parallel to the two capacitors 21,22 is a resistance 23,24 with a high value to enable the capacitors 21,22 to be discharged when the circuit is switched off.

It will be apparent that due to the dual function of the self-induction the number of components is considerably reduced compared to a prior art circuit. The circuit is thus simplified.

The operation of the compensation devices 17,18 is such that a pulse-like voltage with a broad frequency spectrum is provided by the frequency converter to the input terminals of the compensation devices. Due to the fact that the lamps 15,16 are extinguished, only the first part of the inductance 19 and 20 is energized, which part forms a resonant circuit together with capacitor 21 respectively 22. This resonant circuit is dimensioned such that the individual frequency of the resonant circuit lies at least within the spectrum of the signal provided by the frequency converter, so that resonance occurs. As a consequence of this resonance a high voltage will be generated in the other part of the inductance 19 respectively 20, and this is so high that the lamps 15,16 are ignited. The lamps will then burn normally, wherein the ballast exercises its actual stabilizing function.

It will be apparent that diverse changes can be made to the circuit shown. It is thus possible for instance to connect a single gas discharge lamp to one frequency converter, but it is equally possible to connect a much larger number of gas discharge lamps to one frequency converter. This latter embodiment in particular is attractive for assimilation lighting, wherein with a limited number of frequency converters, which must of course be dimensioned for this purpose, a large number of gas discharge lamps can be supplied. Such a situation can for instance also be applied in the case of pylons for public lighting, wherein a large number of lamps, which could be supplied by a single frequency converter, are fixed to one pylon.

It is of course possible to use the frequency converter as dimmer. It is possible herewith to adapt the light output and the energy consumption of the lighting installation to the momentary requirement, for instance as a function of the weather or the season. The latter is particularly important in the case of total energy.

A dimmer function can be obtained by changing the voltage on the intermediate circuit, by pulse width modulation or by changing the repetition frequency of the modulation function.

Figure 2 further shows an embodiment which is particularly suitable for emergency lighting. This circuit corresponds with the circuit shown in figure 1, with the difference that there is only one lamp 15 and a single compensation device 17, while supply takes place by means of a battery or accumulator instead of the electricity mains. The battery takes the place of the rectifier 4. The battery is designated in figure 2 with reference numeral 25. It is of course also possible in this circuit to supply various lamps.

In the circuit shown in figure 2 use is further made of a double bridge, or two half-bridges, instead of the half-bridge used in figure 1. This additional half-bridge comprises transistors 28,29 which are again each provided with a freewheel diode 30,31 respectively and which are each provided with a drive circuit 32,33 respectively. This bridge circuit enables use of a power source which only provides a positive or negative voltage relative to the zero voltage. Such circuits are anyway widely known, for instance in the driving of motors.

In the embodiment shown in figure 2 the capacitor 21 is moreover connected by means of a switch 27 to the other side of the lamp. The control terminal of the switch 27, for which a semiconducting switch such as a triac or a mechanical switch can be used, is connected to the control circuit 13. Another control circuit can of course also be used instead. This switch 27 is switched on during igniting of the lamp. When the lamp is burning, which can for instance be detected by a separate detection circuit, or after a determined period of time, for instance one minute, has elapsed, the switch 27 can be switched off. Hereby is prevented that in case of a defective, and of course non-starting lamp, the ballast is

12. Circuit as claimed in any of the foregoing claims, **characterized in that** the frequency converter is adapted to supply more than one gas discharge lamp and that a ballast and an ignition circuit is arranged for each of the gas discharge lamps.

13. Circuit as claimed in any of the foregoing claims, **characterized in that** a second inductive ballast is connected in series to the inductive ballast, wherein the second inductive ballast has a lower induction than the first inductive ballast and that the second inductive ballast has a greater saturation current than the first inductive ballast coil.

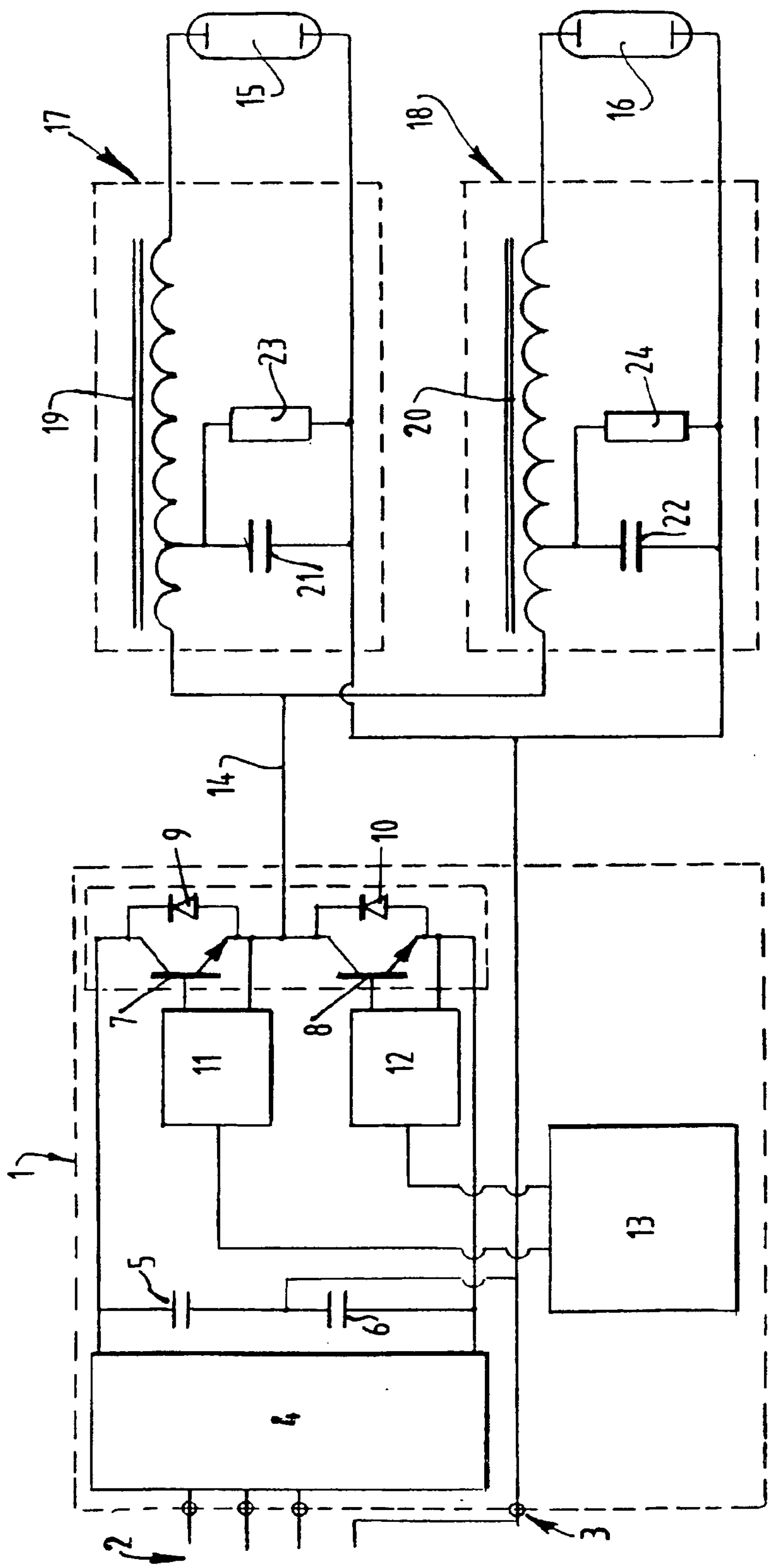

FIG.1

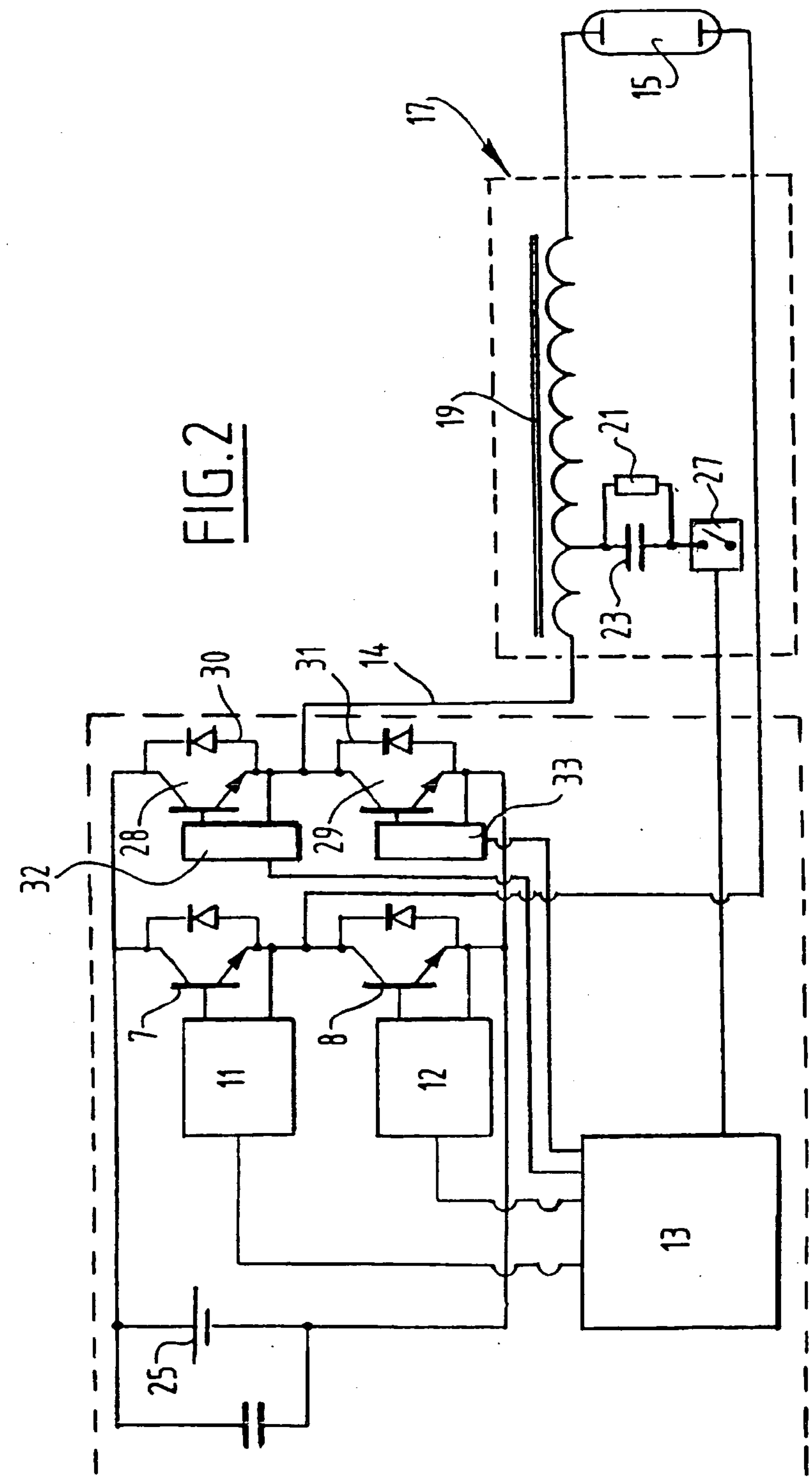

FIG.2

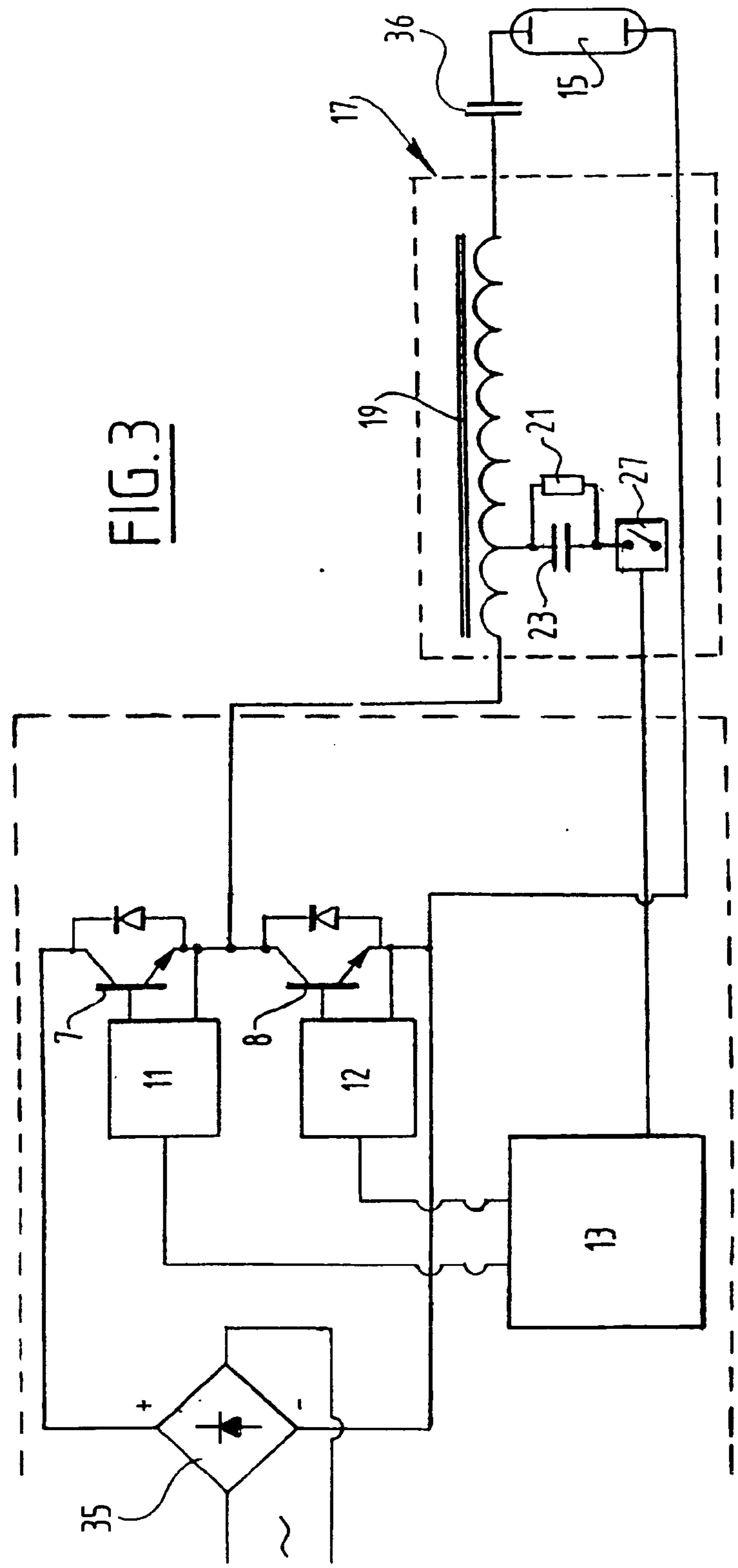

FIG.3

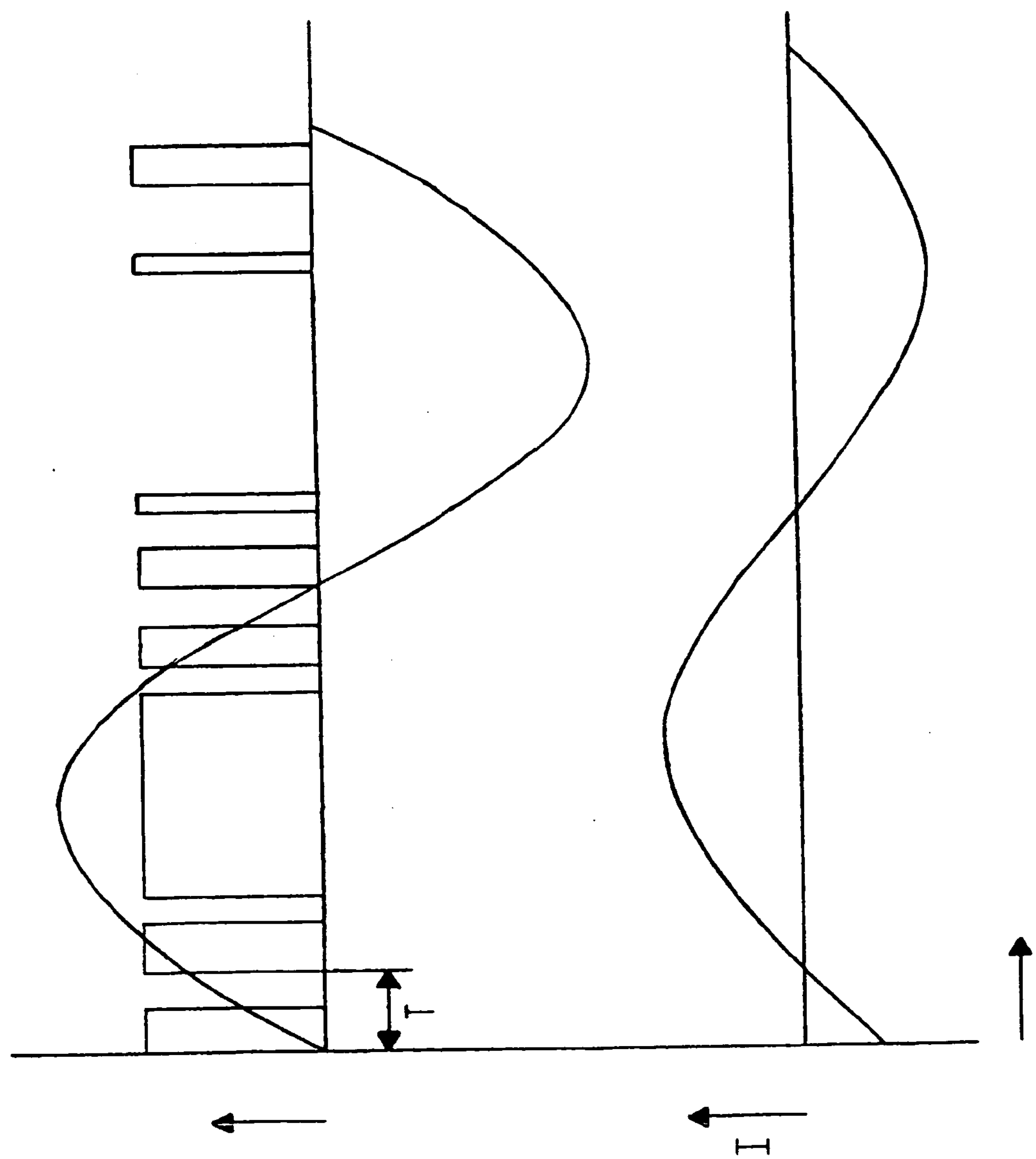

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 96 20 0985

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE-A-40 15 400 (HELLA HUECK) * column 1, line 25 - column 2, line 52; figure 2 * ---	1-3,13	H05B41/29 H05B41/38
X,P	DE-A-43 35 375 (THOMSON BRANDT GMBH) 20 April 1995 * column 2, line 13 - column 2, line 20 * * column 3, line 2 - column 3, line 3; figure 1 * ---	1-3,6,13	
A	US-A-5 381 076 (NERONE) * column 6, line 55 - column 7, line 55; figure 1 * ---	1,6,7	
A	EP-A-0 358 191 (TOSHIBA) * figures 1,5 * ---	9,10	
A	US-A-4 924 150 (NILSSEN) * figures 3,4 * ---	9,11	
A	DE-A-41 27 970 (ROBERT BOSCH) * abstract; figure 1 * ---	13	**TECHNICAL FIELDS SEARCHED (Int.Cl.6)** H05B H02M
A	DE-A-43 13 195 (MITSUBISHI) -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 July 1996	Speiser, P

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